The Impact of Adopting Time-of-Day Tolling

Case Study of 183A in Austin, Texas

Thomas Light, Sunil Patil, Gregory D. Erhardt, Flavia Tsang, Peter Burge,
Paul Sorensen, Mia Zmud

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Published by the RAND Corporation, Santa Monica, Calif.

Preface

Through a grant from the Federal Highway Administration's Value Pricing Pilot Program, the Central Texas Regional Mobility Authority (CTRMA) asked RAND to evaluate time-of-day pricing on the 183A Turnpike in Texas. RAND was tasked with studying the implications for traffic congestion on the broader highway network, of both tolled and nontolled roads. To conduct the analysis, a stated preference survey was administered and model estimation and scenario testing were conducted to understand how motorists would respond to alternative tolling arrangements. This report summarizes the approach and findings from RAND's analysis and is intended to inform decisionmakers at CTRMA as well as the broader transportation research community.

Related RAND research includes the following:

- Thomas Light, "High Occupancy Toll Lane Performance Under Alternative Pricing Policies," *Journal of the Transportation Research Forum*, Vol. 51, No. 2, Summer 2012, pp. 61–82.
- Liisa Ecola and Thomas Light, *Equity and Congestion Pricing: A Review of the Evidence*, Santa Monica, Calif.: RAND Corporation, TR-680-EDF, 2009.

The RAND Transportation, Space, and Technology Program

The research reported here was conducted in the RAND Transportation, Space, and Technology Program, which addresses topics relating to transportation systems, space exploration, information and telecommunication technologies, nano- and biotechnologies, and other aspects of science and technology policy. Program research is supported by government agencies, foundations, and the private sector.

This program is part of RAND Justice, Infrastructure, and Environment, a division of the RAND Corporation dedicated to improving policy and decisionmaking in a wide range of policy domains, including civil and criminal justice, infrastructure protection and homeland security, transportation and energy policy, and environmental and natural resource policy.

Questions or comments about this report should be sent to the project leader, Thomas Light (Thomas_Light@rand.org). For more information about the Transportation, Space, and Technology Program, see http://www.rand.org/transportation or contact the director at tst@rand.org.

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Summary

This project evaluates the traffic and revenue impacts of moving from a fixed toll rate on the 183A Turnpike in Texas to a toll structure that varies by time of day. By shifting to a toll structure that varies by time of day, the Central Texas Regional Mobility Authority (CTRMA) hopes to encourage motorists to shift their departure times to off-peak periods to reduce congestion elsewhere in the transportation network. At the same time, CTRMA is constrained in its ability to raise toll rates or implement changes in the toll rate structure that would reduce the financial viability of the facility. CTRMA asked RAND to evaluate whether it is possible to reduce 183A tolls in off-peak periods so as to reduce downstream traffic congestion (on the Missouri-Pacific [MoPac] Expressway) while maintaining or exceeding the current revenue level.

To facilitate this research, a survey was conducted in 2014 to collect information on current and potential users of 183A and to elicit information on their travel preferences. Discrete choice models were developed from the survey data. These formed the basis of a prediction tool developed by the study team to quantify how motorists' departure times and route choices may change in response to changes in the 183A tolling structure. The tool has been calibrated to transaction data for 183A and license plate reader (LPR) data collected from the 183/183A corridor to facilitate estimation of traffic and revenue impacts associated with modifying the current toll structure between 5 a.m. and noon in the southbound direction.

Our findings suggest that shifting to time-of-day tolling on 183A is not likely to meet CTRMA's objectives, given the constraints it faces. Specifically, we find that:

- Reducing off-peak toll levels on 183A will reduce revenues, although the losses are likely to be small for modest reductions in off-peak toll levels.
- Charging lower off-peak toll rates causes a very small portion of trips to shift from peak to off-peak travel. Rather than shifting departure times, motorists are more likely to shift from the parallel, untolled roadway (183) to the tolled 183A when off-peak toll rates are reduced. Consequently, reducing off-peak toll rates has little effect on peak-period traffic conditions on 183 or on downstream facilities, such as MoPac.
- To remain revenue neutral, modest reductions in off-peak toll levels will need to be accompanied by modest increases in peak toll rates.

Acknowledgments

This research was funded through a grant from the Federal Highway Administration's Value Pricing Pilot Program. The report has benefited from helpful discussions with a variety of people, including Kris Keith of HNTB Corporation, William Ihlo and Ann Hughitt of Stantec, and Tim Reilly of the Central Texas Regional Mobility Authority. A number of colleagues at RAND have helped improve this research, including Keith Crane, Hui Lu, and Johanna Zmud. Charlene Rohr of RAND and José Holguín-Veras of Rensselaer Polytechnic Institute reviewed this report and provided feedback that greatly improved its quality.

CHAPTER ONE

Introduction

This project evaluates the traffic and revenue impacts of moving from a fixed toll rate on the 183A Turnpike in Texas to a toll structure that varies by time of day. By adopting a toll structure that varies by time of day, the Central Texas Regional Mobility Authority (CTRMA) hopes to encourage motorists to shift their departure times from peak to off-peak periods, in order to reduce congestion elsewhere in the transportation network. At the same time, decisionmakers are constrained in their ability to raise toll rates or implement changes in the toll rate structure that would reduce the financial viability of the facility.

Our findings suggest that shifting to time-of-day tolling on 183A is not likely to meet CTRMA's objectives, given the constraints it faces. Specifically, we find that:

- Reducing off-peak toll levels on 183A will reduce revenues, although the losses are likely to be small for modest reductions in off-peak toll levels.
- Charging lower off-peak toll rates causes a very small portion of trips to shift from peak to off-peak travel. Rather than shifting departure times, motorists are more likely to shift from using the parallel, untolled roadway (183) to the tolled 183A when off-peak toll rates are reduced. Consequently, reducing off-peak toll rates has little effect on peak-period traffic conditions on 183 or on downstream facilities, such as the Missouri-Pacific (MoPac) Expressway.
- To remain revenue neutral, modest reductions in off-peak toll levels will need to be accompanied by modest increases in peak toll rates.

To facilitate this research, the study team conducted a survey in 2014 to collect information on current and potential users of 183A and elicit information on their travel preferences. Using the survey data, the study team developed a prediction tool to quantify how motorists' departure times and route choices change in response to changes in the 183A tolling structure. The tool has been calibrated to other data collected from the 183/183A corridor to facilitate the estimation of traffic and revenue impacts associated with modifying the current toll structure. The study focuses on modeling the traffic impacts between 5 a.m. and noon in the southbound direction.

Background

Like many other urban areas around the United States, Austin's transportation system primarily consists of its highway and street network, with some tolled facilities but many more nontolled roads. Because of political and legislative constraints, transportation agencies in Texas have limited near-term flexibility to address increasing congestion by pricing the most heavily congested roads and corridors. At the same time, local sustainability goals and physical space limitations have made adding new capacity very difficult.

The 183A Turnpike is located in southwestern Williamson County. The turnpike traverses the cities of Leander and Cedar Park, as well as the northern border of Austin, generally parallel to and east of U.S. 183. U.S. 183 is not tolled. Users of the 183/183A corridor can choose between either route. 183A offers faster travel through the corridor than 183 but requires that motorists pay tolls. Over the past eight years, Williamson County has been ranked as either the second- or third-fastest growing county in the state. Routes 183 and 183A connect to several nontolled roads that feed into central and south Austin. Several of the roads between the 183/183A corridor and Austin become very congested during the morning and evening commute periods.

The 183A Turnpike, CTRMA's first transportation improvement project, opened to traffic in March 2007, and traffic and revenue have consistently exceeded forecasts since the first year of operation. It is an 11.6-mile toll highway facility serving regions northwest of Austin, Texas, and it is being implemented in phases. The initial phase, which was completed in 2007, consists of 4.5 miles of a six-lane tolled highway with intermittent frontage roads, along with 7.1 miles of two-lane frontage roads extending to the northerly limits of the project. The second phase, which was completed in 2012, consists of a 5.1-mile extension for the six-lane tolled highway, with associated access ramps connecting to the existing frontage roads. The project has been funded by a combination of Texas Department of Transportation (TxDOT), federal, and local mechanisms, including a Transportation Infrastructure Finance and Innovation Act (TIFIA) loan, as well as toll revenue bonds.

The toll paid by 183A users varies depending on where motorists enter and leave the facility. The toll also depends on whether the motorist pays for use electronically with a TxTag device or via mail.[1] Drivers who pay electronically pay 25 percent less than those that pay via mail. Furthermore, toll charges increase with the number of vehicle axles. For example, someone with a TxTag who travels the entire length of the 183A in a two-axle vehicle will be charged $2.91. The $2.91 charge is made up of three separate toll charges, which are assessed when the vehicle travels through the Crystal Falls, Park Street, and Lakeline toll gantries on the 183A mainline. If a two-axle vehicle using these segments of 183A paid via mail, the charge would be $3.87.

A recent traffic survey conducted by CTRMA indicates that motorists traversing the 183/183A corridor in the southbound direction during the morning peak via 183A took between nine and 12.5 minutes, while using 183 took on average 18.5 minutes. That is, motorists saved between six and 9.5 minutes if they used 183A to traverse the corridor during the morning peak in the southbound direction (Central Texas Regional Mobility Authority, 2013).

Based on recorded traffic flow patterns on 183A, much of the population in this area commutes into Austin. With major employers, such as the University of Texas and state government facilities located in central Austin, one can assume that traffic on 183A during peak periods is significantly commuter driven. The survey discussed in the next section suggests that

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[1] TollTag and EZ TAG devices are also accepted for making electronic toll payments and are charged the same rate as TxTag customers.

approximately 70 percent of southbound motorists in the 183/183A corridor are traveling for work, employer business, or school.

CTRMA would like to know whether it can implement time-of-day pricing on 183A to indirectly affect traffic congestion on the broader highway network of both tolled and nontolled roads. Changes to the tolling structure on 183A must be made in the context of a number of constraints. In particular, any modification to 183A's toll structure must be approved by the facility's Revenue Bond Trustee and CTRMA's Board of Directors. Decisionmakers have indicated a strong preference for any shift to time-of-day tolls to be revenue neutral or positive. Furthermore, there is a preference to not increase tolls during any time of day above the current flat-rate level. This study was conducted for CTRMA to investigate the traffic and revenue impacts of reducing off-peak toll levels on 183A from the current flat level.

A more general aim of this study is to contribute to the literature by providing a deeper understanding of road users' behavioral responses to time-of-day pricing. Although the concept of road pricing has been around since the 1920s, the research community is still grappling with road users' complex, multidimensional behavioral responses. As explained by Holguín-Veras and Allen (2013), this lack of thorough understanding of the behavioral impacts of pricing "stems from the fact that the number of actual implementations of road pricing is very small, and that only a portion of these are the subject of behavior research." The approach taken in this study—stated preference survey and discrete choice modeling—has an important role to play in improving this behavioral understanding (see the discussions in Parsons Brinckerhoff, Inc., et al., 2013; Perez et al., 2012; and Parsons Brinckerhoff, Inc., et al., 2012). Methodologically, this study is similar to the approach undertaken in Holguín-Veras and Allen (2013) and other prior studies (e.g., Yamamoto et al., 2000). Nevertheless, the 183A Turnpike in Texas provides a unique opportunity for studying road users' behavioral response to time-of-day pricing in a choice context in which a free, close-to-parallel alternative route is available. Additionally, the somewhat unique revenue and tolling constraints facing CTRMA make analysis of time-of-day pricing on 183A interesting from a public policy perspective.

Outline of the Remainder of This Report

This report summarizes our analytical approach and findings. Chapter Two describes our analytical approach, including the survey that was conducted, our choice modeling approach and findings, and the calibration of the traffic and revenue model that was developed to estimate the impacts of changing the toll rate structure on 183A. Chapter Three summarizes the finding from our traffic and revenue analysis. Chapter Four provides concluding remarks.

Modeling Motorists' Responses to Toll Changes

To support our tolling analysis, users of the 183/183A corridor were contacted and asked to complete a survey. The survey collected information about respondent demographics, travel behaviors, and experiences using 183A. As part of the survey, respondents were asked to participate in two stated preference experiments. The first choice experiment elicited information about motorists' value of time by asking respondents to indicate their preferences for two travel options that differ in their travel times and monetary costs.[1] The second choice experiment was more complex and asked respondents to choose between different departure times and route options in the context of their most recent southbound trip in the 183/183A corridor. The responses to the second stated preference experiment were used to estimate choice models quantifying motorists' preferences for 183 and 183A under alternative time-of-day pricing schemes. The choice models were used as the basis of a traffic and revenue model tailored to 183A and 183.

This chapter describes the development of the traffic and revenue model, beginning with the development of the survey that supported the traveler choice modeling.

183/183A Travel Survey

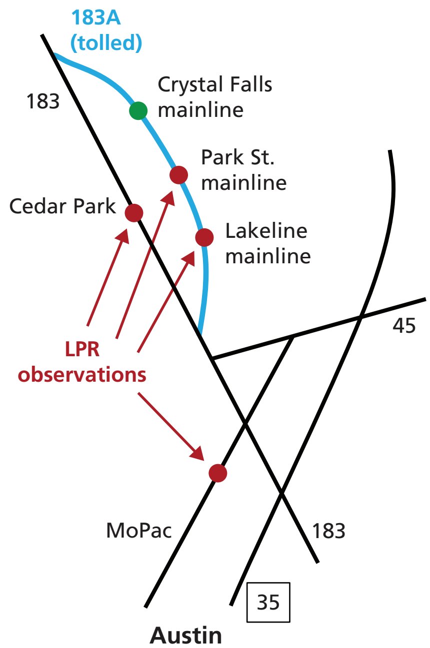
To identify households to be contacted for the 183/183A survey, we leveraged license plate reader (LPR) data. The LPR data were collected during the morning peak period (approximately 6 a.m. to 10 a.m.) over the course of five weekdays during November 2012. The LPR data were collected at four locations, as shown in Figure 2.1, three of which are located in the 183/183A corridor (at the Park Street and Lakeline mainline locations on 183A and at Cedar Park on 183). From the four LPR locations, 73,192 unique license plates were recorded; 48,982 of those, or 67 percent of the total, were observed at least once at one of the three LPR locations in the 183/183A corridor.

The set of households recruited to participate in the 183/183A survey was derived from the LPR data. Specifically, we drew a random sample of 10,000 license plates from a subset of the 48,982 unique license plates observed in the 183/183A corridor.[2] These license plates were

[1] The value of time represents the monetary value that travelers place on saving time spent traveling. It is useful for predicting motorists' choices between routes that differ in terms of travel times and monetary costs. It is also useful for evaluating the benefits of transportation investments that seek to improve travel times for motorists.

[2] In deriving the sample of 10,000 license plates, we excluded vehicles registered outside of nearby counties in Texas, vehicles registered in the name of a company, and trucks.

Figure 2.1
License Plate Reader Locations



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then matched with addresses and phone numbers when available.[3] We were able to obtain phone numbers for approximately 40 percent of households in our sample.

Survey Execution

The survey was administered online. A version of the survey was piloted in January 2014. In mid-February 2014, the final version of the survey was administered. Participants were contacted via mail with instructions about how to log on and take the survey, and phone messages alerting households to the survey were sent to those participants for whom we had phone numbers. In mid-March 2014, we sent a second mailing to the 9,868 households in our survey frame, which provided a $10 incentive to complete the survey. Finally, at the beginning of April, follow-up phone calls were made to participants that again alerted them of the survey and the incentive for participating. The survey was closed at the end of April 2014 with 551 completed survey responses, or a response rate of approximately 5.5 percent.

Respondent Demographics

Table 2.1 summarizes key demographic variables for the respondents. Men represent a larger proportion of the survey participants than women. The majority of respondents fall in the 35-to-64 age range. Travelers in the corridor tend to have relatively high income, with more

[3] It is important to note that our sample excludes those who do not use the 183/183A corridor because (1) they did not make any trips to a relevant destination, (2) they were not auto users, or (3) they used more disparate routes. Because of this, our analysis does not consider the behavior of people who may switch destinations, switch modes, or change routes from outside the corridor. We assume that any destination, mode, and major route effects are small relative to the time-of-day and toll/no-toll choices induced by a change in the toll rate structure on 183A.

Table 2.1
Demographics for Survey Respondents

Respondent Characteristic	Number of Respondents	Share of Respondents (%)
Gender		
Male	315	57
Female	216	39
Prefer not to say	20	4
Age		
18–24	1	0
25–34	53	10
35–44	132	24
45–54	152	28
55–64	131	24
65–74	61	11
75 or over	13	2
Prefer not to say	8	1
Annual gross household income ($)		
34,999 or less	16	3
35,000 to 49,999	27	5
50,000 to 74,999	74	13
75,000 to 99,999	75	14
100,000 to 199,999	188	34
200,000 or more	36	7
Prefer not to say	135	25

than half of the respondents reporting a gross household income of more than $100,000 per year. As one might expect, respondents were less likely to report their incomes than their genders and ages.

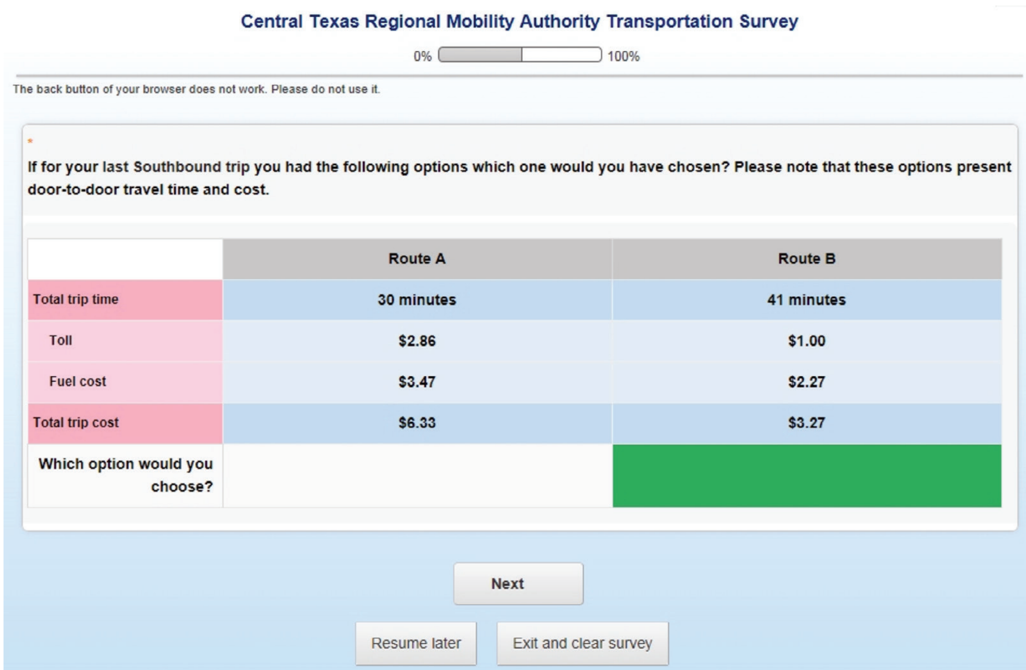
Fifty-nine percent of respondents reported that their employer allows flexible work hours. On average, respondents' households own 2.4 vehicles. Of respondents who reported race, 86 percent are white, 6 percent are Hispanic, 4 percent are Asian, 2 percent are black, and 2 percent are other.

The survey data show that 34 percent of respondents (187 of 551 respondents) used 183A during their last southbound trip in the corridor, which is roughly consistent with the LPR data used to develop the survey population. In addition, simple tabulation of the survey data suggests that women, younger motorists, and high-income motorists are more likely to use 183A. The statistical significance of these effects were tested in the choice model estimation (discussed in the next section).

Stated Preference Choice Model

The stated preference experiments used the traveler's last southbound trip in the corridor as a reference and asked the traveler to consider different times and costs for making that trip. A screenshot of the first experiment for one respondent is shown in Figure 2.2. This choice

Figure 2.2
Choice Experiment Designed to Obtain Information About Motorist's Value of Time



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experiment focused on how motorists made trade-offs between time savings and cost savings by asking the traveler to choose from two routes, each associated with different travel times and costs. Each respondent was asked to evaluate six pairs of such routes.

An example of the screen for the second stated preference experiment is shown in Figure 2.3. This experiment focused on a combination of departure time and route choices. In this experiment, the departure time of the respondent's last southbound trip is taken as the preferred departure time, and options are given to shift from that preferred departure time for different levels of tolls and travel time on 183A. Travelers were given a choice of traveling before the peak, in the early peak shoulder, in the peak, in the late peak shoulder, or after the peak. In addition, travelers were given the option of choosing a nontolled route in the 183 corridor at their preferred departure time. Each respondent was presented with six different versions of the second choice experiment.

Choice Model Estimation

Discrete choice models were developed to simultaneously predict both the traveler's departure time choice and route choice (tolled or not tolled) from the second choice experiment. The models specifically apply to southbound trips in the 183A corridor between 5 a.m. and noon. The models were estimated as nested logit models using the structure shown in Figure 2.4.[4]

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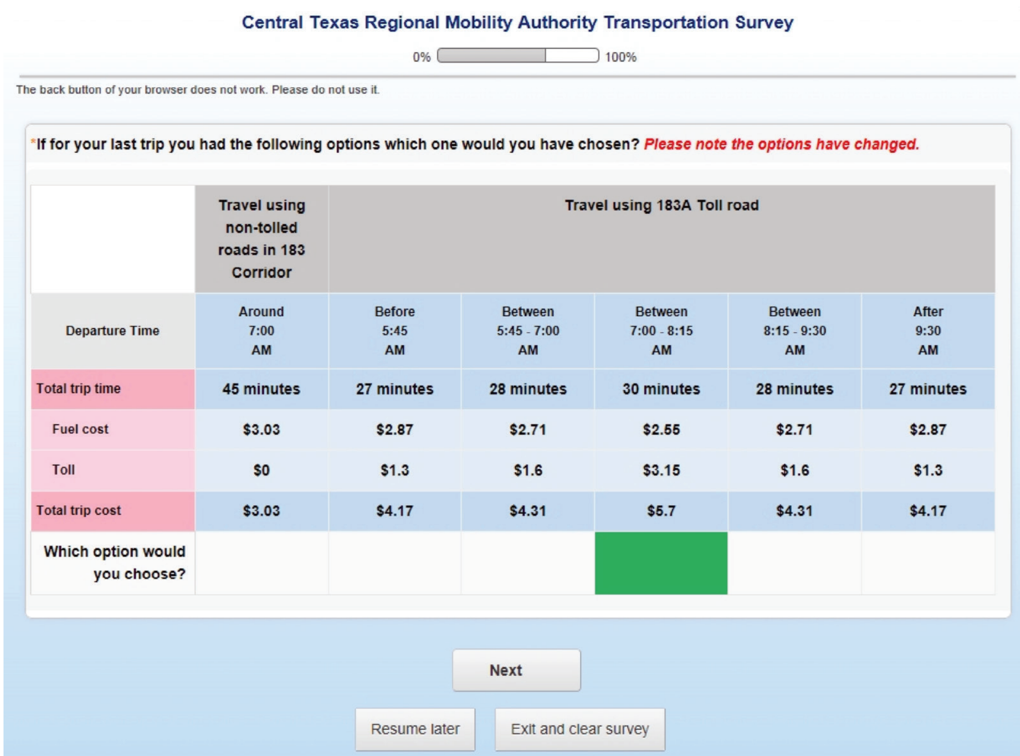
[4] We tested the models with two possible nesting structures. One included the choice of time periods lower in the nesting structure, and the second included the choice of routes (toll versus no toll) lower in the nesting structure (as shown in Figure 3.4). The model with the choice of time periods lower in the nesting structure resulted in an estimated nesting coefficient of 1.01 for the mandatory trips model, which we rejected as not significantly different from a multinomial logit model. In contrast, including the route choice lower in the nesting structure revealed a nesting coefficient of approximately 0.75

Figure 2.3
Choice Experiment Designed to Obtain Information About Motorist's Value of Time and Departure Time Preferences


Central Texas Regional Mobility Authority Transportation Survey

0% 100%

The back button of your browser does not work. Please do not use it.

*If for your last trip you had the following options which one would you have chosen? *Please note the options have changed.*

	Travel using non-tolled roads in 183 Corridor	Travel using 183A Toll road				
Departure Time	Around 7:00 AM	Before 5:45 AM	Between 5:45 - 7:00 AM	Between 7:00 - 8:15 AM	Between 8:15 - 9:30 AM	After 9:30 AM
Total trip time	45 minutes	27 minutes	28 minutes	30 minutes	28 minutes	27 minutes
Fuel cost	$3.03	$2.87	$2.71	$2.55	$2.71	$2.87
Toll	$0	$1.3	$1.6	$3.15	$1.6	$1.3
Total trip cost	$3.03	$4.17	$4.31	$5.7	$4.31	$4.17
Which option would you choose?						

Next

Resume later | Exit and clear survey

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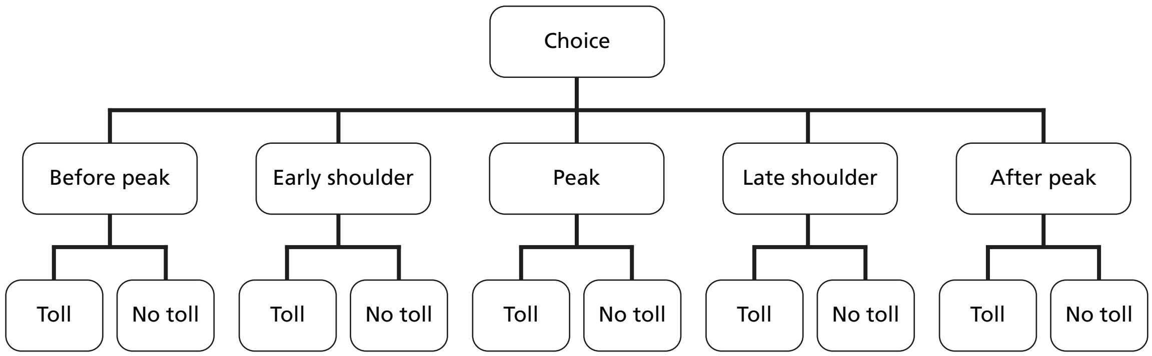
The choices are to travel in one of five time periods, via a toll or no-toll route, for a total of ten possible combinations. These models were estimated using the combined route and time-of-day choice experiment data (i.e., the second choice experiment). As with the design of the experiment, the model was set in the context of the traveler's last southbound trip and took the departure time for that observed trip as the ideal departure time.

Only trips within the 5 a.m.-to-noon window were included in the model estimation and subsequent application. Consistent with the design of the experiment, only the no-toll alternative in the same period as the current departure time is available. The route choice is lower in the nesting structure than the time-of-day choice, indicating that the data reveal that travelers are more likely to switch routes than switch time periods.

Separate models were estimated for mandatory versus nonmandatory trips. The survey data indicated that mandatory trips, which include work, employer business, school, and escorting others to school, cover about 70 percent of trips in the corridor. These trips are grouped because their nature implies that they are compulsory and often have limited schedule flexibility. The 30 percent of nonmandatory trips include purposes such as shopping, personal business, recre-

(which is statistically different from 1.0 with greater than 95-percent confidence), as well as better goodness-of-fit measures, for the mandatory model. We selected this latter model as having better explanatory power. This structure means that there is a higher cross elasticity between route-choice alternatives than between time-of-day alternatives. In other words, travelers are more willing to substitute between taking the 183 versus 183A than substitute between different time-of-day alternatives. We adopted the same nesting structure for the nonmandatory trip model.

Figure 2.4
Model Nesting Structure for Estimation



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ation, health care, visiting others, and a range of other specific purposes. Nonmandatory trips are typically observed to have lower values of time and more schedule flexibility than mandatory trips. A number of different specifications were tested in our analysis. Table 2.2 shows a summary of the mandatory and nonmandatory trip models used in our traffic and revenue model. The travel time and cost coefficients for the mandatory model imply an average value of time of $12.13 per hour (–0.1060 x 60 minutes/–0.5244). For the nonmandatory trip model, we observed enough carpool trips to allow differentiation of the value of time for single- and higher-occupancy vehicles. For single-occupancy vehicles and carpool vehicles making nonmandatory trips, the estimates of the value of time are $6.89 per hour (–0.0770 x 60 minutes/ –0.6705) and $10.28 per hour (–0.0770 x 60 minutes/[–0.6705 + 0.2209]), respectively.

Estimates of value of time derived from similar studies tend to vary widely, ranging from 20 to 90 percent of the average gross wage rate among respondents (Small and Verhoef, 2007). In general, the literature has found that estimates of motorists' value of time derived from stated preference data are considerably smaller than those obtained from revealed preference data. For example, Brownstone and Small (2005) find that values of time obtained from discrete choice models estimated from stated preference data are on the order of half to a third as large as those obtained from revealed preference data. Because our analysis is based on stated preference data, we would expect that our value of time estimates to be lower than estimates obtained using revealed preference data for motorists in region.[5]

A set of time-shift variables shows the penalty travelers perceive for shifting from their ideal departure times. A number of different specifications were tried for the mandatory and nonmandatory models before a final specification was selected. The terms for shift and for the segment of shift above 60 minutes are additive. Figure 2.5 shows the total effect in equivalent dollars for both models. For example, for mandatory trips, the incentive (or cost savings)

[5] This is confirmed when we compared our estimated values of time against those implicit in the regional travel demand model used by CTRMA to project future traffic. For example, in that model, single-occupancy home-based work trips have a value of time of $18.48 per hour during peak periods and $12.32 per hour during off-peak periods. Both these estimates fall above our mandatory trip value of $12.18 per hour. It should also be noted that we offered a $10 monetary incentive to some participants if they completed our survey. While we do not anticipate that this biased the participant group greatly, we acknowledge that the monetary incentive may have caused money-sensitive individuals (with lower values of time) to be more likely to participate.

Table 2.2
Estimated Model Coefficients for Mandatory Trips

	Mandatory Trips		Nonmandatory Trips	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Travel time (minutes)	−0.1060**	(0.0229)	−0.0770*	(0.0428)
Cost of tolls ($)	−0.5244**	(0.1241)	−0.6705**	(0.3034)
Cost of tolls if vehicle occupancy 2+ (additive with cost of tolls)	—		0.2209	(0.2333)
Shift earlier than current departure time to reach alternative (minutes)	−0.0582**	(0.0117)	-0.0459	(0.0357)
Shift later than current departure time to reach alternative (minutes)	−0.0502**	(0.0107)	—	
Shift earlier, segment above 60 minutes of shift	0.0481**	(0.0143)	—	
Shift later, segment above 60 minutes of shift	0.0295*	(0.0152)	—	
Shift earlier, segment above 120 minutes of shift	—		0.0276	(0.0603)
Shift later, segment above 120 minutes of shift	—		—	
Shift later, up to a maximum of 120 minutes	—		−0.0054	(0.0096)
Person is female, applied to no-toll alternative	−0.4641**	(0.2182)	−0.4456	(0.4193)
Bias toward no-toll alternative	1.333**	(0.2781)	1.4578**	(0.5463)
Time period nest	0.7254**	(0.0808)	0.7871**	(0.2269)
Observations	2,028		630	
Likelihood with zero coefficients	−3,634		−1,129	
Likelihood with constants only	−2,293		−633	
Final value of likelihood	−2083		−612	
Rho-squared with respect to zero	0.4266		0.4579	
Rho-squared with respect to constants	0.0915		0.0336	

* Statistically significant at 90-percent confidence level.

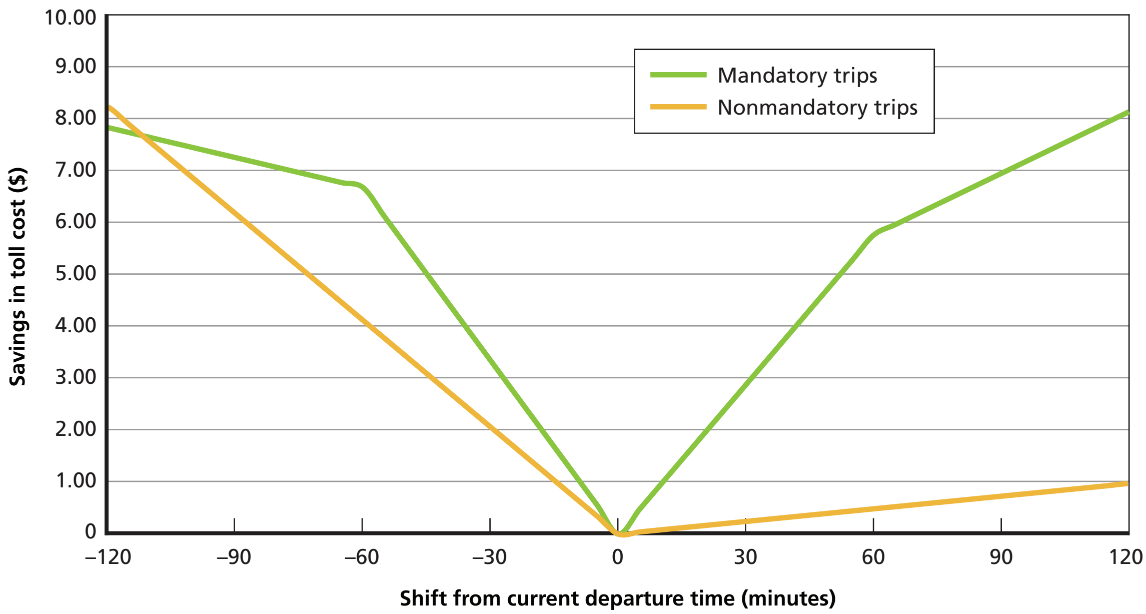
** Statistically significant at 95-percent confidence level.

NOTE: Standard errors are calculated using a bootstrap procedure.

required to shift one hour earlier is $6.66 and $5.75 to shift one hour later. For nonmandatory trips, the incentive required to shift one hour earlier is $4.11 and $0.48 to shift one hour later, according to the choice model.

Tests of alternative demographics variables in the model suggest that women are more likely to use the toll road than men, all else being equal. Other demographic variables such as income, age, and education level tend to not be statistically significant predictors in both the mandatory and nonmandatory trip models.

Figure 2.5
Required Savings to Induce Departure Time Shift



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Traffic and Revenue Model

After estimating the choice models, the models were implemented in a spreadsheet so that alternative toll policy scenarios could be evaluated in terms of their traffic and revenue impacts.[6] The traffic and revenue model predicts the probability of *when* motorists will travel and *whether* they will use the untolled (183) or tolled route (183A) under different tolling schedules. For the purposes of calculating the probability of motorists' choices, we assume that respondents travel the entire corridor distance and will save approximately seven minutes in travel time if they opt to use 183A.

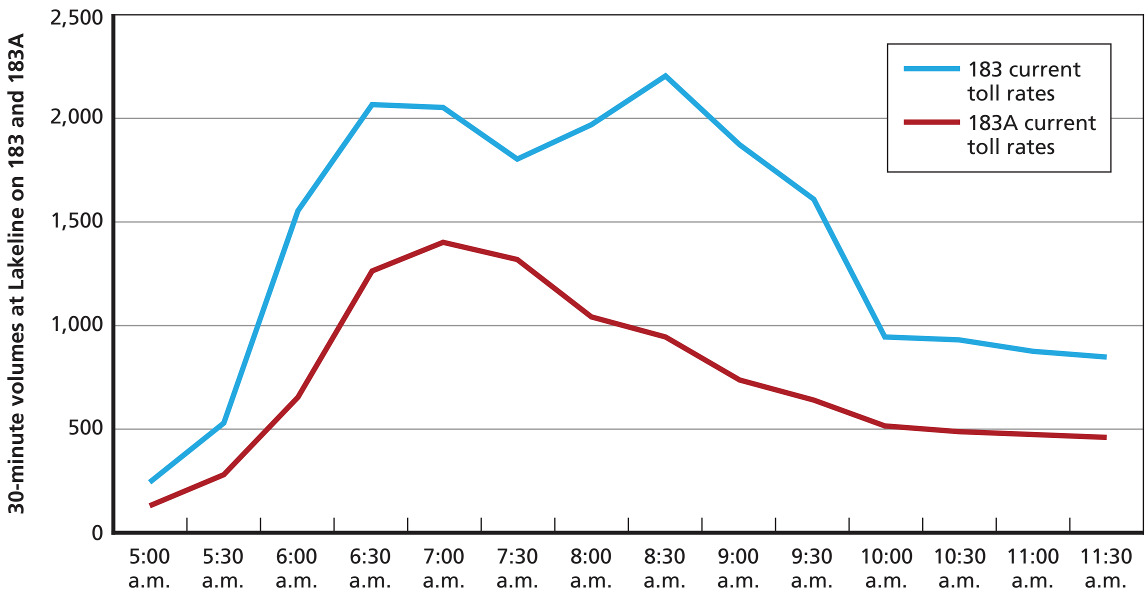
The model was calibrated to the following data made available to the study team:

- the LPR data for 183 from November 2012
- half-hour transaction data for 183A from May 2014
- historical 183A transaction and revenue summary data available on CTRMA's website.

We assigned weights to each respondent such that the corridor's southbound diurnal traffic distribution in the model replicated the traffic volume observed in the LPR and 183A transaction data. We also adjusted the parameter representing the preference for the toll road by time period to replicate the observed route split. Figure 2.6 shows the model's baseline traffic patterns on 183 and 183A, after calibration was performed.

[6] In doing this, the model nesting structure was adapted so that the time-of-day nests include each of the 14 half-hour periods between 5 a.m. and noon. This structure allows us to specify toll rates in any combination for those half-hour periods to test different peak and off-peak pricing schemes, while avoiding the need to group the periods into the five more aggregate definitions used above.

Figure 2.6
Baseline Diurnal Traffic Patterns on 183 and 183A After Calibration



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For the purpose of extrapolating revenue, we scaled the revenue estimate generated by the model to account for the fact that some motorists only use part of the facility or pay via mail. This adjustment is based on the relationship between actual and projected southbound weekday morning revenue, which was obtained when we simulated activity during May 2014.

The model is designed to calculate the traffic and revenue impacts on a typical weekday between 5 a.m. and noon in the southbound direction. The traffic impacts that are summarized occur on 183 and 183A at Lakeline (at the southern end of the facility). The traffic and revenue model specified the cumulative toll required to use all three mainline segments in the southbound direction by a two-axle vehicle with a TxTag in 30-minute increments. In the calibrated model, the daily weekday revenue generated in the southbound direction between 5 a.m. and noon is approximately $29,200.

CHAPTER THREE

Modifying 183A Tolls

We used the model described in the previous chapter to investigate the traffic and revenue implications of adjusting tolls on 183A. In this chapter, we first explore the implications of proportionally raising or lowering the tolls on 183A during all time periods. While this does not directly address the research question posed to us by CTRMA, it provides useful information about the overall sensitivity of users of the 183A facility to changes in the toll level. Next, we explore the effect of reducing toll levels during the off-peak periods. Finally, we identify the set of revenue neutral peak and off-teak toll combinations.

Varying the Flat Toll Levels

How sensitive is revenue to changes in the current flat toll rates? To analyze this question, we varied the flat-toll levels on 183A within our traffic and revenue model.

Figure 3.1 shows our model's predictions of how demand for travel varies at the southernmost end of the facility in the southbound direction according to changes in the toll level. The elasticity of demand for 183A with respect to the toll level at current toll rates is −0.85, according to our model.[1] This suggests that a 10-percent increase in the toll level will lead to an 8.5-percent reduction in 183A utilization. The level of price sensitivity implied by our model is high in relation to other estimates of the price elasticity of demand for toll roads. Nevertheless, we would expect it to be higher than the elasticity observed on toll roads where motorists have few alternative travel options (see, for example, Matas and Raymond, 2003, and Hirschman et al., 1995).

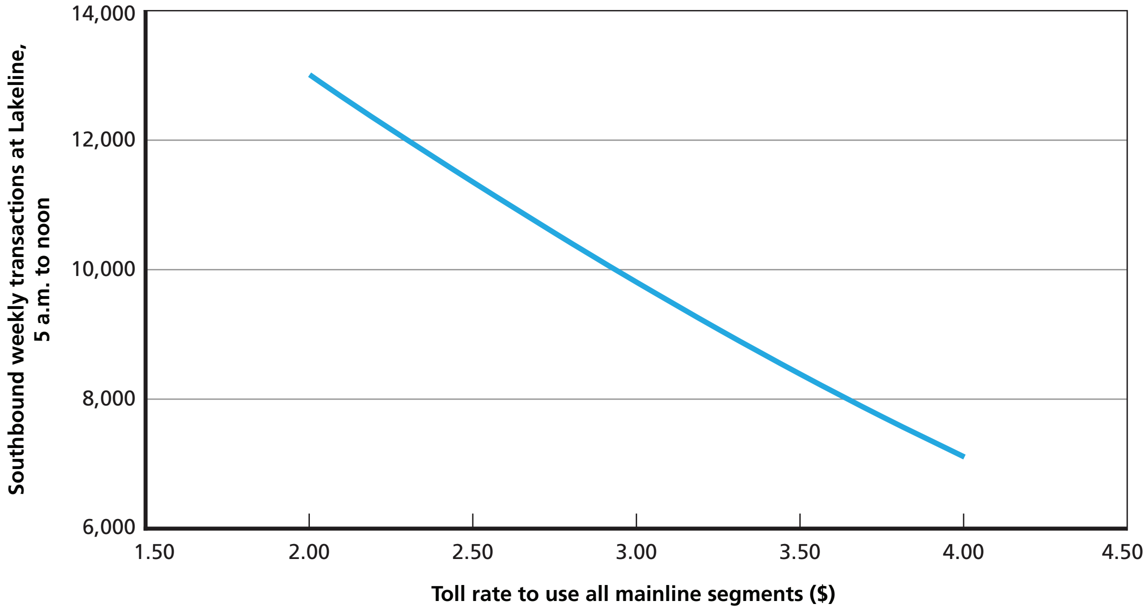
Figure 3.2 shows the changes in revenue obtained from southbound motorists between 5 a.m. and noon on weekdays as the toll level varies; this applies to motorists with a TxTag in a two-axle vehicle on all three mainline segments.[2] The analysis suggests that revenues will increase if tolls are raised from their current level of \$2.91 up until they reach \$3.28. After that point, revenue would start to decline as the toll rate is increased, due a growing decline in the number of toll road users.

It is important to note that raising the toll level to the revenue-maximizing level of \$3.28 will increase revenues by only 1 percent (from approximately \$29,200 to \$29,500).

1 This represents the probability weighted average impact of a toll change on respondents, derived using the choice models discussed in Chapter Two.

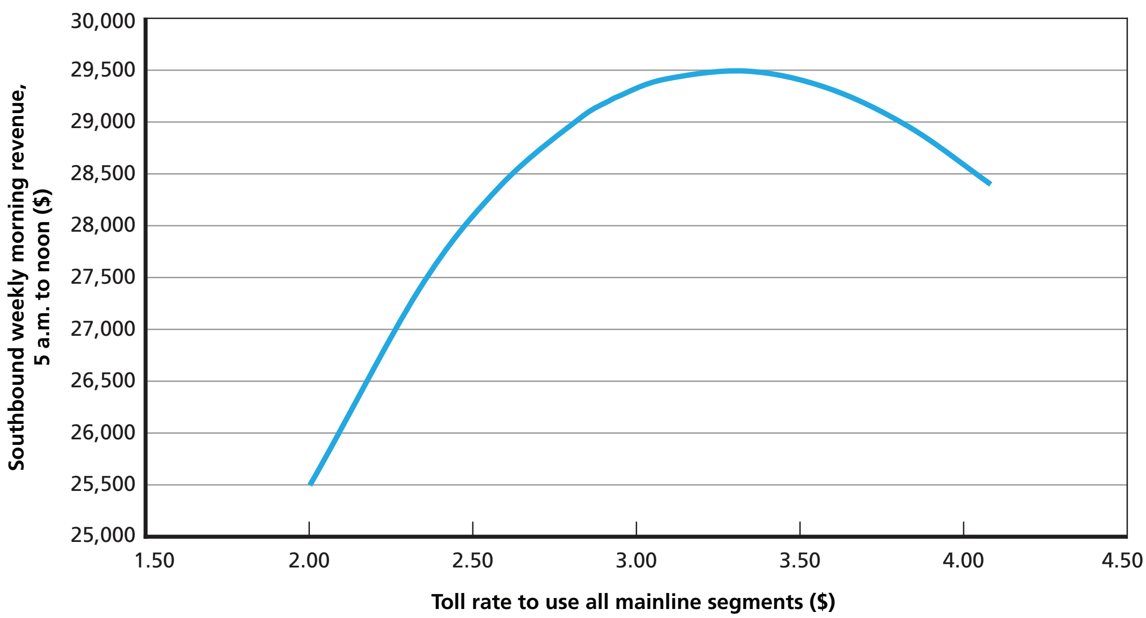
2 We assume that other toll charges collected on intermediate on- and off-ramps will vary proportionally with the mainline toll charges.

Figure 3.1
Relationship Between Weekday Southbound 183A Transactions at Lakeline Between 5 a.m. and Noon and Flat Toll



RAND *RR969-3.1*

Figure 3.2
Relationship Between Daily Weekday Southbound Morning Revenue (5 a.m. to noon) and Flat Toll Level



RAND *RR969-3.2*

That is, according to our modeling, the facility is currently operating near its revenue-maximizing level—there would be only a modest increase in revenues obtained by raising rates during the morning peak.

In the cases of 183A, motorists have access to 183 and other free alternative routes. In fact, a majority of corridor users avoid paying tolls on 183A by using 183. This can be seen in Figure 3.3. Overall, utilization of 183A is projected to decline by 11 percent when the flat-toll level is increased to the revenue-maximizing level.

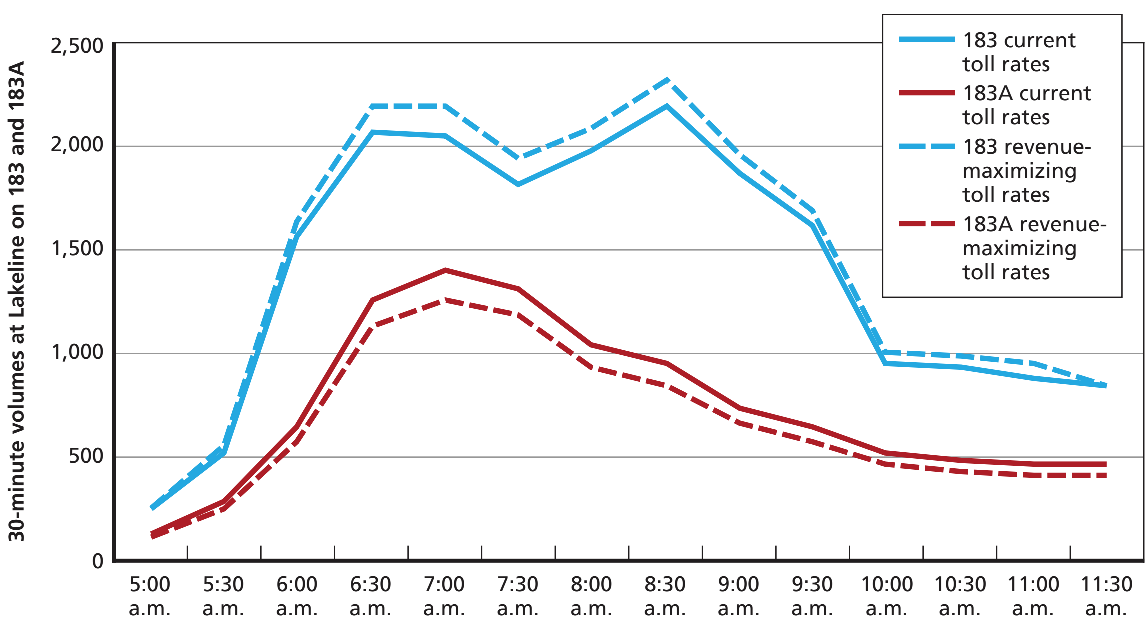
Reducing Off-Peak Tolls

CTRMA is limited in its ability to raise toll rates. If time-of-day pricing is to be implemented, it would likely take the form of reduced off-peak rates.

In our analysis we considered three alternative definition of the morning peak and off-peak period. They are:

- two-hour morning peak from 7 to 9 a.m. (off-peak from 5 to 7 a.m. and from 9 a.m. to noon)
- three-hour morning peak from 6 to 9 a.m. (off-peak from 5 to 6 a.m. and from 9 a.m. to noon)
- four-hour morning peak from 6 to 10 a.m. (off-peak from 5 to 6 a.m. and from 10 a.m. to noon).

Figure 3.3
Change in Traffic Volumes Associated with Increasing 183A Toll Levels to Revenue-Maximizing Level



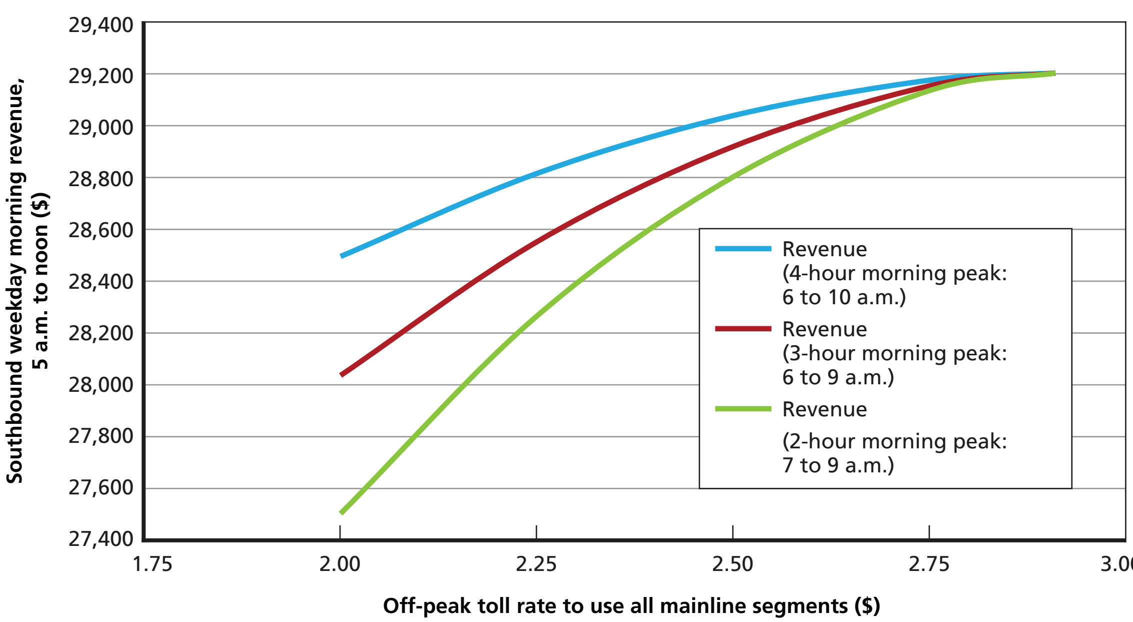
NOTE: Current toll rate = $2.91; revenue-maximizing toll rate = $3.28. This applies to use of all three mainline segments with a TxTag as and a two-axle vehicle.
RAND *RR969-3.3*

Figure 3.4 shows how revenue obtained between 5 a.m. and noon on a typical weekday would change in response to reduced off-peak toll rates. Again, we report the total toll cost to use all three mainline segments with a TxTag and assume that all toll rates would fall proportionally. As shown in the Figure 3.4, revenues will decline with a reduction in off-peak toll levels. The reductions are moderate, however. For example, reducing off-peak toll rates to $2.00 from $2.91 to use all three mainline segments would cause revenues to decline by between 2 and 6 percent, depending on which definition of peak and off-peak is adopted.

Would reducing off-peak toll rates cause motorists to shift their departure times to off-peak periods? As an example, Figure 3.5 shows how reducing off-peak toll rates affects traffic patterns on 183 and 183A at Lakeview when a two-hour peak period is adopted (7 to 9 a.m.); in this scenario, it would cost $2.25 to use all three mainline segments during off-peak periods. The figure suggests that peak traffic on both 183 and 183A would be relatively unaffected, but off-peak volumes would shift from 183 to 183A under the lower off-peak toll rates. This finding was robust to alternative definitions of the peak and off-peak period and to the size of the reduction in the off-peak toll level.

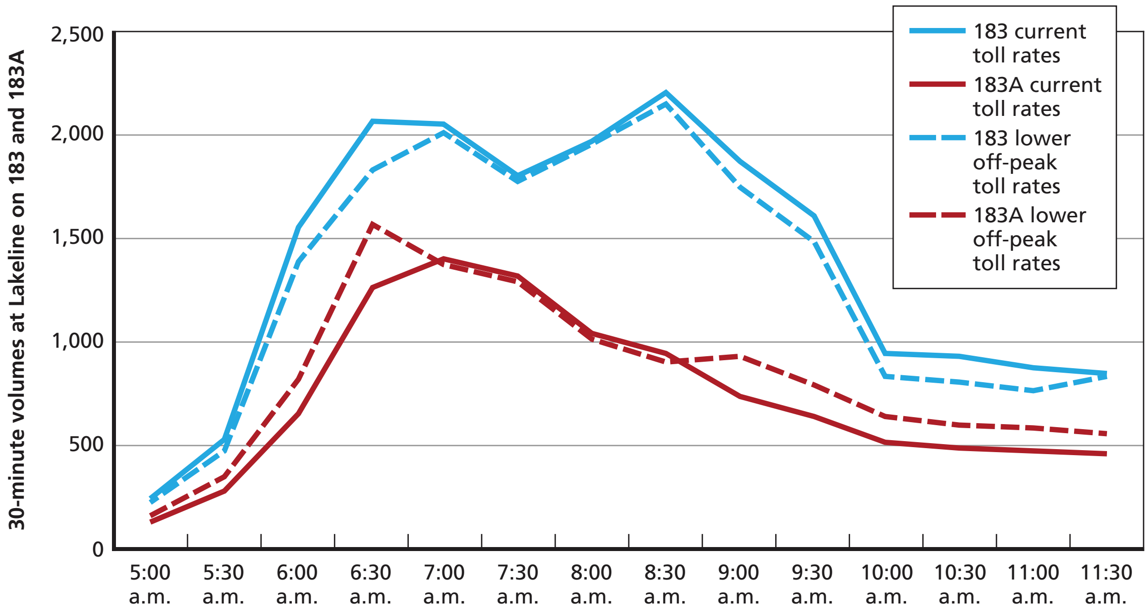
Figure 3.6 shows what happens to the total volume of traffic exiting the corridor by time period under a reduction of off-peak toll rates to $2.25 and a two-hour peak definition. The figure suggests almost no change in overall traffic patterns exiting the corridor as a result of the off-peak toll reduction—the dashed line and the full line in the figure overlap almost everywhere. This suggests that the $0.66 toll savings ($2.91–$2.25) to travel during the off-peak period would not be enough to induce a meaningful shift in motorists' departure times.

Figure 3.4
Daily Weekday Southbound Morning Revenue (5 a.m. to noon) Impacts of Reducing Off-Peak Toll Rate



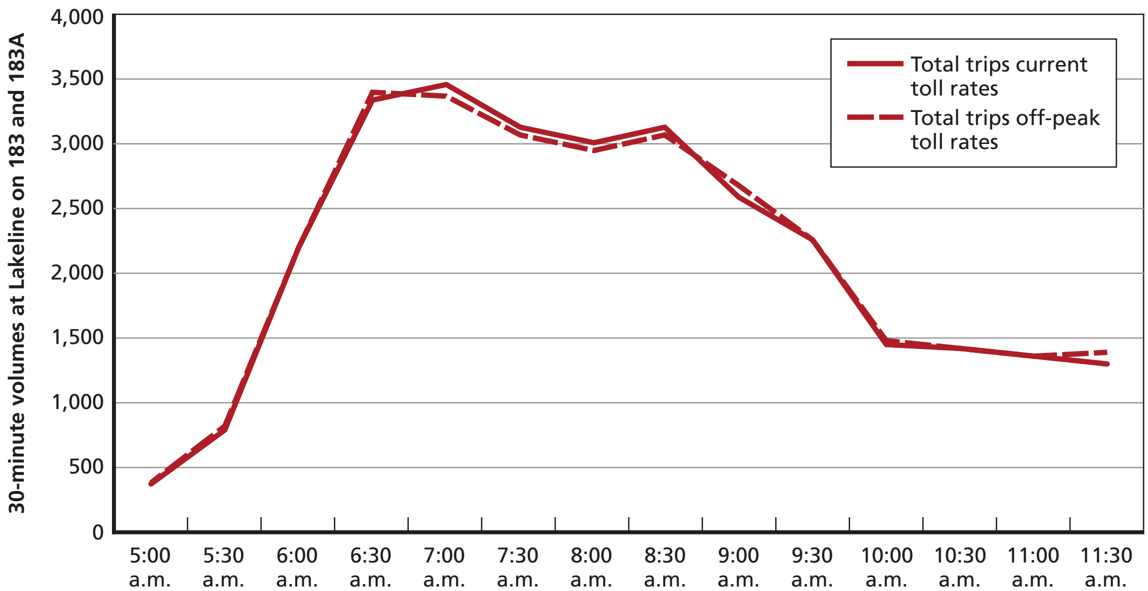
RAND *RR969-3.4*

Figure 3.5
Change in Traffic Volumes Associated with Reducing Off-Peak Toll Levels to $2.25 to Use All Three Mainline Segments



NOTE: Assumes two-hour a.m. peak (7 to 9 a.m.) with off-peak tolls reduced to $2.25 to use all three mainline segments.
RAND *RR969-3.5*

Figure 3.6
Change in 183 and 183A Traffic Volumes Associated with Reducing Off-Peak Toll Levels on 183A to $2.25 to Use All Three Mainline Segments



NOTE: Assumes a two-hour a.m. peak (7 to 9 a.m.) with off-peak tolls reduced to $2.25 to use all three mainline segments.
RAND *RR969-3.6*

Revenue Neutral Time-of-Day Tolls

In the previous section, we showed that revenues would decline if off-peak toll rates are lowered. That leads us to ask, what peak and off-peak toll combinations maintain revenue neutrality?

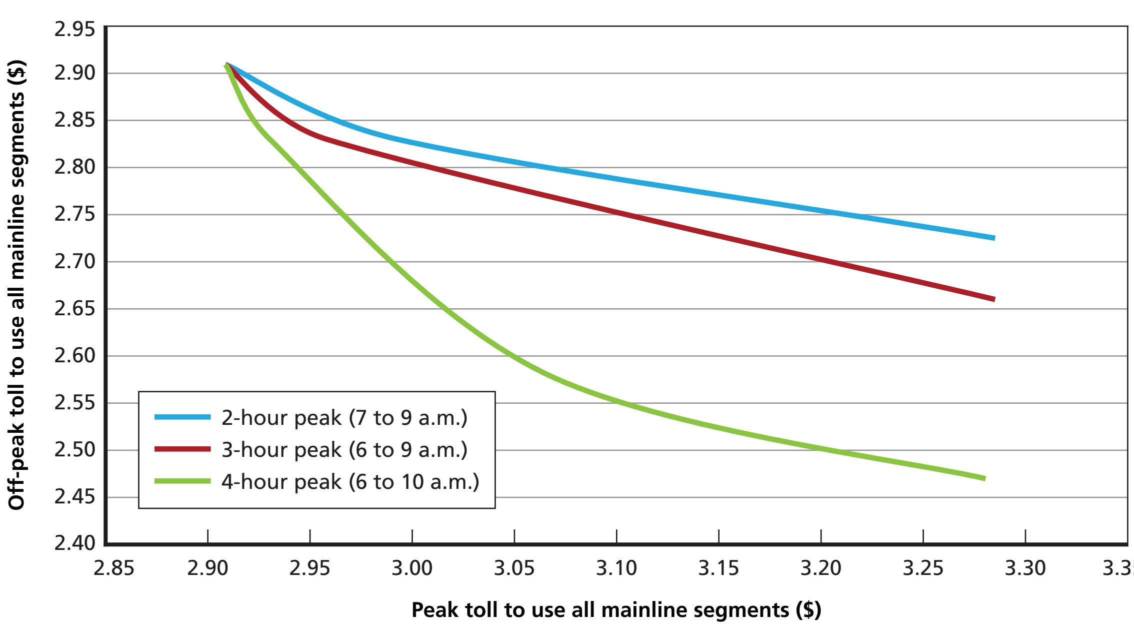
Figure 3.7 identifies the toll combinations that maintain the current revenue level under different definitions of the morning peak and off-peak. For example, with a three-hour morning peak, a drop in the off-peak toll rate to $2.75 to use all three mainline segments would need to be accompanied by an increase in the peak toll rate to $3.10 to remain revenue neutral. The wider the peak period considered, the less the peak period toll must be increased to offset the revenue loss from reducing off-peak toll rates. For large reductions in the off-peak toll levels, it may not be possible to make up the lost revenues by increasing peak toll rates. For example, with a two-hour morning peak, if off-peak tolls drop below $2.72 to use all three mainline segments, there is no offsetting increase in peak toll rates that can maintain revenue neutrality.

Caveats

In light of the findings presented in this chapter, it is useful to highlight a few important caveats.

First, early on in this analysis, CTRMA and the study team agreed to limit the scope of the analysis to the morning period in the southbound direction to ensure that the research could be completed in a timely fashion with available resources. While we expect that impacts for the evening peak and off-peak periods would be similar, they have not been analyzed and could be different. For example, the evening peak tends to be wider and includes more discretionary trips. This could cause results to differ from those found for the morning peak period.

Figure 3.7
Revenue-Neutral Peak and Off-Peak Toll Combinations



RAND *RR969-3.7*

Second, the analysis leverages modeling performed on stated preference data. One might be concerned that motorists will overstate their sensitivity to changes in the toll level in an effort to discourage the tolling authority from increasing rates. Nevertheless, if we modified our traffic and revenue model to make motorists less sensitive to changes in the toll rate (i.e., lower the elasticity of demand for travel on 183A with respect to the toll rates), we would find that reducing off-peak toll rates would lead to greater losses in revenue than reported here. That is, with more inelastic demand for 183A, reducing toll rates would draw fewer new users off of 183 and onto 183A, leading to greater losses in revenue than projected here.

Third, our modeling assumes that travel times on 183 and 183A are fixed, regardless of the number of motorists that shift between 183 and 183A. As the corridor becomes more congested, relaxing this assumption in future modeling efforts will become more important. We leave this for future research.

CHAPTER FOUR

Conclusion

This study has sought to inform CTRMA on the traffic and revenue impacts of shifting to time-of-day toll rates on 183A. One of the primary goals of adopting time-of-day pricing is to reduce congestion elsewhere in the transportation network by causing motorists to shift their travel from peak to off-peak periods. CTRMA is constrained in its ability to raise toll rates during any period of the day, but it can reduce toll rates if those reductions do not reduce revenues. As a result, CTRMA is interested in understanding whether off-peak toll levels on 183A could be reduced without reducing revenues.

With regard to CTRMA's question, our research implies the following:

- If off-peak tolls are reduced, revenue will decline. The size of the reduction in revenue depends on how peak and off-peak are defined in terms of time.
- Reductions in off-peak tolls cause a very small portion of trips to shift from peak to off-peak travel. Rather than shifting departure times, motorists are more likely to shift from using 183 to 183A when off-peak tolls are reduced. Consequently, reducing off-peak toll rates has little effect on peak-period traffic conditions on 183 or on downstream facilities, such as MoPac.
- To remain revenue neutral, modest reductions in off-peak toll levels would need to be accompanied with modest increases in peak toll rates.

Abbreviations

CTRMA	Central Texas Regional Mobility Authority
LPR	license plate reader
MoPac	Missouri-Pacific
TIFIA	Transportation Infrastructure Finance and Innovation Act
TxDOT	Texas Department of Transportation

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